College of Engineering

Georgia Institute of Technology

Atlanta, Georgia

NASA-IGT PREDOCTORAL DESIGN TRAINING PROGRAM

GRANT NOS. NGT 11-002-064 and NGR 11-002-081

P R O G R E S S R E P O R T

AUGUST 31, 1969 - AUGUST 31, 1970

September 1970

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I. INTRODUCTION

August 31, 1970 terminates the third year of the NASA Design Traineeship Program at Georgia Institute of Technology. A total of ten Trainees were supported directly by NGT 11-002-064; one Trainee in the program is on the regular NASA Traineeship (NSGT-1). During the reporting period one Trainee left the program and graduate school for financial reasons.

During the year the Interurban Air Transportation study was published and distributed. The five Trainees working in this area have formulated their research topics and are well along on their research, however, completion of these dissertations will take from six months to a year. As of August 31, 1970 all of the Trainees on the original grant had completed all requirements (qualifying exams, foreign language, course work and comprehensive exam) except the dissertation. Robert Gordy has completed his course work and his qualifying exam and is taking his taking his comprehensive exam currently but has not received the results. He is scheduled for the foreign language exam in October 1970. Bill Pugh has passed his qualifying exam and is scheduled for his foreigh language exam in October 1970. He has 21 quarter hours of course work remaining and no comprehensive exam as such is required in ME. Bill Crichton is in the process of taking his comprehensive exams.

Three of the trainees made extended trips during the period of this report. Charles Andrews and Roscoe Hinson visited Langley Research Center during the period December 1-12 and Lester Dozier during the period of December 2-12. Mr. Andrews and Hinson also visited the FAA in Washington during January 5-6 and November 24-26 respectively. These visits proved very valuable in introducing the trainees to the current state of the art.

A study of solid waste collection and disposal was completed by a group of ten graduate students in June 1970 and a final report has been edited and will be printed soon.

This report has been prepared by Dr. Steve L. Dickerson, Project Coordinator with the assistance of Dr. Virgil Smith (A.E.) and Dr. Thomas White (E.E.) who are part of the principal staff carrying out the program and doing the teaching in it. Other faculty members who have been involved in the program are Professor Don W. Dutton (A.E.), Mr. Gary Draper (I.S.E.), and Dr. Joseph Talavage (I.S.E.).

II. TRAINEE STATUS AND PROGRAMS

Those Trainees who have received graduate credit at Georgia Tech during the reporting period are as follows:

Name	Program Beginning	Major	G.P.A.	Quarter Hours Completed
Charles R. Andrews	1967	EE	3.4	122
Lester D. Dozier	1967	ME	3.1	103
Richard W. Hess	1967	ME	3.6	95
Roscoe M. Hinson	1967	ME	3.7	69
Harvey C. Taylor	1967	ME	3.9	92
William I. Crichton, Jr.	1968	ISE	3.8	84
Robert S. Gordy	1968	EE	3.7	83
William E. Pugh III	1968	ME	3.5	71
E. Kevin Dahill	1969	ME	3.3	40
David E. Ferguson	1969	ISE	3.5	33
Edward B. Stephens	1969	ISE	3.3	21

Edward Stephens left Georgia Tech at the end of the Winter Quarter primarily for financial reasons. Dave Ferguson is terminating his graduate work with the masters degree and has been replaced by Mr. Stephen L. Stumph (ISE) effective Fall 1970. Also entering the program Fall 1970 at the second year level are Mr. Francis W. Skwira and Mr. Carroll S. Kirkpatrick, both in Mechanical Engineering.

The following pages give an itemized accounting of the academic record of the Trainees during the reporting period.

CHARLES RENEAU ANDREWS

Courses Taken

Fall 1969

Air	411	Advanced Air ROTC	B	3
EE	800	Thesis		

Winter 1970

Air	412	Advanced Air ROTC	A	3
EE	702	Seminar	S	
EE	800	Thesis		

Spring 1970

Air	413	Advanced Air ROTC	A	3
EE	703	Seminar	S	
EE	800	Thesis		
Math	695	Laplace Transfrm	A	3

Summer 1970

EE	800	Thesis	-	12

"Approach Control as a Differential Games Problem"

Charles Andrews

One of the most pressing problems in the air transportation system is how should air traffic in a terminal area be controlled. Presently aircraft are guided in and out of terminals by air traffic controllers, and the resultant delay and amount of safety that occur depend mostly on the experience of the controllers. In order to minimize delay while maintaining a desirable degree of safety, it may be possible to determine the optimal trajectories planes should fly. The control variables necessary to determine these trajectories then could be fed back to the planes. One approach to obtain these optimal paths is to consider the takeoff and landing problem as a cooperative differential game. Once the problem is formulated, it can be reduced to an optimal control problem. Some difficulties arise because of the large number of parameters and inequality constraint equations, in the system. To be practical the paths must be determined faster that real time. This research involves the approach and departure structure of the Atlanta Airport where there are four approach lanes and completely separated from the approaches four departure lanes. Each approach lane is to be considered a source of planes and a player in the differential game.

LESTER DOHN DOZIER

Courses Taken

Fall 1969

ME	800	Thesis	-	9
ML	101	Elementary German	V	3

Winter 1970

ME	800	Thesis	-	12

Spring 1970

AE	456	Vibration & Flutter	V	3
AE	671	Turbulence Atmospheric Dynamics	V	3
ME	800	Thesis	-	6

Summer 1970

ME	800	Thesis	-	12

"Differential Game Theory Applied to the Category III All Weather Landing Problem for STOL Vehicles"

Lester Dozier

The search for systems capable of landing A/C in all types of weather conditions has progressed leisurely since WWII. In spite of this relaxed approach progress has been made in essentially every aspect of the landing problem. Throughout these years of development, standard (i.e. classical) analytical practices and techniques were incorporated in predicting the landing performance of an aircraft under adverse weather and other system error conditions. The time consuming nature of this approach plus the recent accelerated interest in V/STOL vehicles demands that other more economical and efficient analytical tools be developed for use in analyzing the landing problem in general and the all-weather landing problem in particular. To this end the techniques of optimal control theory have been explored, but difficulty in defining and weighing the performance index parameters has hindered its acceptance and progress. It is, therefore, the objective of this thesis to explore the here-to-fore untapped potential of differential game theory in solving many problems associated with the all-weather landing task. In particular answers to basic questions like; What is the probability of successful landing under the most adverse weather conditions and how do we maximize this? What are the relationships between STOL port design parameters and aircraft performance if the STOL port is to accomodate all weather landings? Under what conditions would it be impossible to land and simultaneously impossible to initiate a go-around? These and other questions as related particularly to STOL vehicles will be investigated so as to determine the feasibility and/or utility of differential game theory in analytical investigations of the all-weather landing problem.

RICHARD WAYNE HESS

Courses Taken

Fall 1969

ME	800	Thesis	-	9
ML	201	Intermediate German	W	3

Winter 1970

ME	800	Thesis	-	12

Spring 1970

ME	800	Thesis	-	12
Phs	626	Science Techniques	V	3

Summer 1970

ME	800	Thesis	-	12
French	001	Elementary French for Graduate Students	V	5

"Strategies for the Sequential Packing of Random Sized Rectangles"

Richard W. Hess

Reducing the cost associated with the packaging and packing of products for sale and shipment to customers has been a major concern of industries for many years. Typically, industries resort to elaborate sophisticated automatic sorting, collecting, packing, and wrapping equipment to reduce these costs. That is, of course, if an industry is fortunate enough to produce a nice, neat, regular, box - or cylindically - shaped product in a sufficient quantity to be able to economically justify the necessary automation.

Some industries, however, do not manufacture a product or render a service that easily lends itself to automation. These industries usually have to deal with the problem of packing a mixture of objects of different sizes and shapes. The Post Office Department and the water, land, and air transportation industries are obvious examples of organizations in this predicament.

Currently the only effective way to deal with the problem of packing a mixture of objects of different sizes and shapes in a given container is to manually pack them using a trial-and-error strategy.* Also there does not seem to be any concerted efforts to replace this manual operation with automatic equipment. The research proposed here is to investigate and define some strategies that can be used to efficiently pack a container with random sized objects. Since this research is the initial excursion into this problem area, only a simplified packing process will be examined.

The simplified packing process that will be examined in this research will be constrained by the following assumptions:

1. Only two-dimensional rectangles and rectangular containers will be considered.
2. The packing strategy will consider only one rectangle at a time, and once the rectangle is assigned a position in the container, it cannot be moved.

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* There is the completely analogous problem of "unpacking" which is not discussed here. Suppose for instance random sized rectangles must be cut out of a large rectangle on a first come first serve basis.

3. When placing a rectangle in a possible packing position only those motions along the X and Y directions and in the plane of the rectangular container will be allowed.
4. Sequential packing will continue until a generated rectangle will not fit in the space remaining in the container. At this point the packing process is terminated.

The resulting two-dimensional packing process should provide the essential shape and orientation problems inherent in almost all real packing problems while still avoiding the initially unnecessary complications that accompany the three-dimensional case.

The inherent structure of the packing process defined by the assumptions listed above makes it possible to obtain an optimum packing strategy by applying dynamic programming techniques. But, on the other hand, the difficulties encountered in applying these techniques also limit the size of the problem that can be handled. Therefore, the optimum strategy will be found using dynamic programming for a small 5 unit by 5 unit container. This strategy will then be used as a basis of comparison for other more practical packing strategies that will be empirically devised and studied using Monte Carlo simulation techniques.

ROSCOE McCLENDON HINSON, JR.

Courses Taken

Fall 1969

ME	800	Thesis	-	12
ML	107	Elementary French	V	3

Winter 1970

ME	800	Thesis	-	12

Spring 1970

ME	800	Thesis	-	12

Summer 1970

ME	800	Thesis	-	12
French	001	Elementary French for Graduates	V	5

"A Stocastic Technique for Evaluation of Aircraft Collision Avoidance Strategies"

Roscoe Hinson

One of the major functions of the air traffic control (ATC) system is to provide for the safe operation of aircraft by assuring that adequate separations are preserved. There have been in development for some time, however, systems that would provide an independent back up in the rare occasions when the ATC fails to accomplish this function. These systems are generally referred to as collision avoidance systems (CAS).

Because of the necessity of handling large traffic densities in small areas, air traffic controllers have developed intricate and sophisticated methods of assuring adequate separation that permit the maximum traffic capacity. The high densities has prevented the development of a method by which a machine could provide for a sufficient warning time in the event of a real danger and yet not give excessive false warnings in the normal operation of the ATC. Such warnings presumably result in pilot evasive action which will itself be undesirable from the standpoint of ATC and passenger comfort.

This is the situation that prompted the present work. The theory of preventing collisions is reformulated in an attempt to find a new structure that would permit a machine to analyze a traffic situation using criteria similar to those of a rational human, and therefore reach conclusions concerning potential threats at a more realistic frequency.

To accomplish this purpose it becomes necessary to compute the probability of a collision for various situations, and since collisions are necessarily rare events, a method must be found that can use available data on aircraft movements (none of which involve a collision) to calculate the probability of a collision.

Thus, a major portion of the work will be devoted to making use of available and potentially available traffic data to calculate the probability of a collision. When methods of calculating the probabilities have been determined it is expected that they can be used to provide an improved threat prediction criteria based on balancing reduced collision rates against increased warning frequencies.

HARVEY CARTER TAYLOR

Courses Taken

Fall 1969

Math	691	Calculus of Variations	A	3
Math	692	Integral Transem	A	3
ME	800	Thesis	-	6
ML	201	Intermediate German	V	3

Winter 1970

ME	800	Thesis	-	12
ML	202	Intermediate German	V	3

Spring 1970

ME	800	Thesis	-	12

Summer 1970

French	001	Elementary French for Graduate Students	V	5
ME	800	Thesis	-	12

"Finite Element Analysis of an Axially Symmetric Solid with Non-Planer Plastic Stresses"

H. C. Taylor

The problem under consideration is a detailed stress analysis of a high speed turbine wheel. The investigation centers around a complete analytic computer solution.

The usual approach to the solution of the elastic stresses in a rotating axially symmetric solid is made from a finite difference approximations of the governing differential equations. This method is straightforward and yields good results as long as the problem is considered to be a plane stress problem. If the scope is not limited to plane stress assumptions then the finite difference approximations become very cumbersome. The equations are in general not well mannered and lengthy iterations are required to produce even a rough approximation.

An alternative to the finite difference approximation procedure is a finite elements solution. This is a very powerful approach and it is the method which shall be used.

Finite elements solutions to the problem of an axially symmetric solid exist if the material is considered to be completely elastic. We have developed a working computer solution to the elastic problem which also takes into account thermal as well as external loading. It has produced results which are in agreement within a maximum error of 2% with problems to which an approximate solution can be easily found by finite difference technqiues.

The next step in the development of the computer program will be an extension into the plastic region. Having successfully accomplished this, it is hoped that the effects of creep can be included and a time dependent solution obtained to yield a cyclic stress-strain analysis from which fatigue life may be obtained.

The extent of which these results can be substantiated by experimental data is not known at this time; however, some degree of experimental work will be undertaken.

WILLIAM INNES CRICHTON, JR.

Courses Taken

Fall 1969

EE	654	Systems Design Methods	A	3
EE	771	Feedback Control	A	3
IE	701	Seminar	S	
IE	704	Special Problems	A	3
IE	755	Industrial Dynamics	A	3

Winter 1970

EE	655	Interdisc Design	A	3
EE	772	Feedback Control	A	3
Ie	671	Optimization	B	3
IE	702	Seminar	S	
Math	419	Probability	A	3

Spring 1970

EE	656	Interdisc Design	A	3
EE	773	Feedback Control	V	
IE	674	Dynamic Prog.	A	3
IE	676	Queueing Theory	A	3
IE	703	Seminar	S	
IE	785	Seminar in OR	A	3

Summer 1970

IE	800	Thesis

ROBERT STEPHEN GORDY

Courses Taken

Fall 1969

EE	654	Sys Design Meth	A	3
EE	745	Adv. Electroma Th	A	4
EE	753	Adv. Communi Theo	A	3
Math	601	Applied Math	W	

Winter 1970

EE	655	Interdisc Design	A	3
EE	699	Ph D Exams Prep	V	
EE	746	Adv. Electroma Th	A	4
EE	754	Adv. Communi Theo	A	3
Math	693	Integral Equatns	A	3

Spring 1970

EE	656	Interdisc Design	A	3
EE	747	Adv. Electroma Th	A	4
EE	755	Adv Communi Theo	A	3

Summer 1970

EE	800	Thesis	-	12

WILLIAM EDWARD PUGH, III

Courses Taken

Fall 1969

ME	654	Systems Design Methodology	A	3
ME	669	Materials for Design	A	3
ME	684	Feedback Systems	A	3
ME	700	Thesis	-	3

Winter 1970

ME	655	Complex Systems Design	V	3
ME	661	Advanced Dynamics of Machinery	B	3
ME	700	Thesis	-	6
ME	707	Special Topics	A	3

Spring 1970

Math	411	Advanced Engineering Mathematics	A	3
ME	700	Thesis	-	9

Summer 1970

French	001	Elementary French for Graduate Students	V	5
Math	691	Calculus of Variations	C	3
ME	700	Thesis	-	4

EDWARD KEVIN DAHILL

Courses Taken

Fall 1969

ESM	635	Strength of Materials	A	3
Math	491	Topics from Advanced Calculus	C	3
ME	658	Mechanism Synthesis	B	3
ME	671	Deformation of Metals	B	3
ME	684	Feedback Systems	B	3

Winter 1970

EE	416	Electronic Computation	A	4
Math	420	Vector Analysis	W	3
ME	661	Advanced Dynamics of Machinery	A	3
ME	672	Fabrication Metals	C	3
ME	685	Feedback Systems	B	3

Spring 1970

ME	673	Fabrication of Metals	A	3
ME	686	Feedback Systems	A	3
ME	700	Thesis	-	3
Phs	626	Science Techniques	A	3

Summer 1970

Math	415	Introduction to Probability	C	3
ME	691	Control of Engineering Processes	V	3
ME	700	Thesis	-	4

DAVID EDWARD FERGUSON

Courses Taken

Fall 1969

IE	460	Mgt Systems Design	A	3
IE	625	Engr Economy	B	3
IE	701	Seminar	S	
IE	755	Indus Dynamics	A	3
Math	309	Introduction to Higher Algebra	V	
Math	491	Topics Advanced Calculus	C	3

Winter 1970

IE	603	Methods IE Research	A	3
IE	606	Materials Control	A	3
IE	672	Optimization	B	3
IE	702	Seminar	S	
IE	760	Simulation Techniques	A	3

Spring 1970

IE	649	Design Indus Exp	B	3
IE	700	Thesis 4Qtr Hrs		
IE	703	Seminar	S	
IE	704	Special Problems	A	3
IE	785	Seminar in OR	A	3

Summer 1970

IE	700	Thesis	
IE	650	Response Surface I	V

EDWARD BOWEN STEPHENS

Courses Taken

Fall 1969

IE	649	Design Indus. Exp.	B	3
SyE	680	Systems Engr. Tech I	A	3
Math	491	Topics Advanced Calculus	C	3
ME	684	Feedback Systems	B	3

Winter 1970

IE	603	Meth IE Research	A	3
IE	671	Optimization	B	3
IE	702	Seminar	S	
SyE	682	System Theory I	W	
ME	685	Feedback Systems	A	3

Spring 1970

Not Enrolled

Summer 1970

Not Enrolled

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

OFFICE OF THE REGISTRAR
REGISTRATION AND RECORDS

September 30, 1970

III. CERTIFICATION OF FULL-TIME STATUS

This is to certify that the students listed below registered for full-time graduate status at the Institute during the periods indicated:

Charles R. Andrews, III	Fall 1969 thru Summer 1970
Lester D. Dozier	Fall 1969 thru Summer 1970
Richard W. Hess	Fall 1969 thru Summer 1970
Roscoe M. Hinson	Fall 1969 thru Summer 1970
Harvey C. Taylor	Fall 1969 thru Summer 1970
William I. Crichton, Jr.	Fall 1969 thru Summer 1970
Robert S. Gordy	Fall 1969 thru Summer 1970
William E. Pugh, III	Fall 1969 thru Summer 1970
Edward Kevin Dahill	Fall 1969 thru Summer 1970
David E. Ferguson	Fall 1969 thru Summer 1970
Edward B. Stephens	Fall 1969 thru Winter 1970

A full-time graduate student at the Institute must register for at least 12 quarter hours of work including hours of research and auditing.

Certified by

G.W. Elliott
Assistant Director
Registration and Records

GWE:k

IV. PROJECTS

The project chosen each year is the basis of the two quarter Complex Systems Design Course Sequence and the Ph.D. dissertations of the Trainees. The trainees dissertations are to carry into greater depth some of the more critical problem areas encountered in the preliminary study.

Interurban Air Transportation

The final report of the 1969 Complex Systems Design Course was published in December 1969 and about 300 copies distributed to people involved in the air transportation industry including government personnel. A copy is enclosed as Attachment I. The Georgia Tech Publication Office has distributed an additional 300 copies on request - primarily to alumni. The people involved in the Complex Systems Design Program are anxious to continue work in this area beyond the five Ph.D. dissertations and are attempting to maintain contact with the FAA, DOT (Electronics Research Center), NASA (Langley Research Center), and several of the airlines.

Solid Waste Collection and Disposal

In January 1970, the Complex System Design Class undertook a study of Atlanta Regional waste collection and disposal. A total of twelve graduate students were involved - four from City Planning-Civil Engineering; three from Mechanical Engineering; three from Electrical Engineering; and one each from Industrial and Systems Engineering and from Biology. In contrast to previous years it was decided to use a minimum of outside speakers to get the class up to speed but rather to concentrate on individual research and contacts. However, two speakers from NASA-MSFC were invited to speak and gave valuable presentations. Mr. Benjamin Chereek talked on the "Systems Approach to Engineering Design" on January 13 through 15

and Dr. W. B. Frierson (M.D.) spoke on "Applications of Systems Engineering and Bioengineering to Delivery of Health Care" on February 17. In both cases not only did the class benefit from the talks but many other campus faculty and staff attended the talks or visited with Mr. Chereek and Dr. Frierson in a number of small meetings.

The waste collection and disposal study continued during the Spring Quarter and resulted in a number of recommendations for development and implementation. For example, the study indicated that the Atlanta region should move toward (1) highly automated residential trash and garbage collection, (2) more extensive use of high quality landfill to increase the utility of land and (3) separation of solid wastes to provide for partial recycling. An oral report was given in early June and a written report has been edited and will soon be printed.

Environmental Health

The overall theme of the 1971 project will be environmental health for the Atlanta Metropolitan region. This continues the emphasis of 1970 which concentrated on solid waste collection and disposal. The team will attempt to identify those activities (e.g. solid waste disposal) which contribute to degrading the environment of Atlanta; determine numerical measures of degradation; devleop alternative technological innovations which might reduce the environmental health problem in Metro Atlanta; evaluate costs and benefits of the technological alternatives; and consider means of implementing desirable technological alternatives.

The end objective is to pinpoint those innovations which are both effective and feasible and thus provide guidelines for further research, development and implementation.

The project will be conducted in close cooperation with MACHealth, the Metropolitan Atlanta Council for Health which is the organization directly responsible for comprehensive area wide health planning.

V. OTHER ACTIVITIES

A report entitled "Interdisciplinary Research Topics in Urban Engineering" was published October, 1969. This report was the work of Urban Engineering Study Committee of the American Society for Engineering Education. Two of the six committee members were Mr. Richard Hess and Dr. Steve Dickerson.

Dr. Dickerson presented a paper entitled "Doctorate Engineering Programs at the ASEE Mid-Atlantic Section Fall Meeting on December 6, 1969."

A short course entitled the "Systems Approach to Design" was organized for the first week of September. Dr. Gordon Davis, Dr. Steve Dickerson, Mr. Gary Draper, and Dr. Joseph Talavage were to participate from Georgia Tech. All have been active in the Complex Systems Design Program at Tech. Insufficient registration caused cancellation of this program.

Dr. Joe Robertshaw, a participant in the NASA - University of Houston - MSC, Summer Faculty Systems Design program has jointed the staff in the School of Mechanical Engineering as a Visiting Associate Professor for the 1970-71 calendar year. Dr. Robertshaw is on sabbatical from Provicence College, Rhode Island, and will be working with Dr. Dickerson to develop a text on the Systems Approach to Design.

Dr. Dickerson also consulted for the University of Houston program during the summer of 1970. He is co-author with Dr. C. J. Huang of two papers to be presented at the XXI International Astronautics Congress in October, 1970, that deals with the results of earlier summer NASA programs at the University of Houston - MSC.